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(54) CANISTER PURGE SYSTEM HAVING IMPROVED PURGE VALVE

ABFÜHRUNGSSYSTEM MIT ABFÜHRUNGSVENTIL FÜR EINEN BEHÄLTER

SYSTEME DE PURGE DE RECIPIENTS COMPORTANT UNE SOUPAPE DE PURGE AMELIOREE

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US-A- 4 381 753
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Description

Field of the Invention

[0001] The present invention relates to on-board evaporative emission control systems for internal combustion engine powered motor vehicles. Such systems comprise a vapor collection canister that collects fuel vapor emitted from a tank containing volatile liquid fuel for the engine and a purge valve for periodically purging collected vapor to an intake manifold of the engine.

Background and Summary of the Invention

[0002] Contemporary systems typically comprise a solenoid-operated purge valve that is under the control of a purge control signal generated by a microprocessor-based engine management system. A typical purge control signal is a duty-cycle modulated pulse waveform having a relatively low frequency, such as 10 Hz. The modulation ranges from 0% to 100%. The response of certain conventional solenoid-operated purge valves is sufficiently fast that the valve follows to some degree the pulsing waveform that is being applied to it, and this causes the purge flow to experience similar pulsations. Such pulsations may at times be detrimental to tailpipe emission control objectives since such pulsing vapor flow to the intake manifold may create objectionable hydrocarbon spikes in the engine exhaust. Changes in intake manifold vacuum that occur during normal operation of a vehicle may also act directly on the valve in a way that upsets the control strategy unless provisions are made to take their influence into account, such as by including a vacuum regulator valve. Moreover, low frequency pulsation may produce audible noise that may be deemed disturbing.

[0003] US-A-5 237 980 shows a canister purge solenoid valve that is operated by a duty cycle modulated control signal. US-A-4 085 721 shows a sonic orifice device in a conduit from a vapor collector to an engine intake manifold.

[0004] US-A-4 381 753 discloses an evaporative emission control device according to the preamble of claim 1, having a variable venturi type carburettor which reduces in-burnt components in the exhaust gas. Vaporised fuel stored in a canister containing activated charcoal is 'supplied' to an intake passage of the carburettor via a supply port which is located between the throttle valve and a venturi valve in the intake passage. A valve is disposed in a line connecting the supply port and the canister to control fuel vapour passing through the line.

[0005] It is known that maintenance of sonic flow will make a purge system quite insensitive to typical fluctuations in engine intake manifold vacuum that occur during engine operation. However, insofar as the applicants are aware, the possibility of maintaining sonic flow by configuring the canister purge valve's head and seat to cause sonic flow when the valve is open and the positive pressure across it is in excess of a certain minimum has not heretofore been recognized.

[0006] The present invention relates to an evaporative emission control system according to claim one, with an improved purge valve which is characterized by improved linearity and insensitivity to variations in intake manifold vacuum communicated to the valve so that better control of canister purging can be achieved. In addition to improvements that reside in constructional features of the purge valve, improvements reside in how it is operated by the purge control signal, particularly when the valve is to operate in the direction of closing. An important advantage of the inventive valve is that an additional vacuum regulator valve becomes unnecessary in view of the sonic flow characteristic of the inventive valve.

[0007] The foregoing, along with additional features, and other advantages and benefits of the invention will be seen in the ensuing description and claims which are accompanied by drawings. The drawings disclose a preferred embodiment of the invention according to the best mode contemplated at this time for carrying out the invention.

Brief Description of the Drawings

[0008]

Fig. 1 is a longitudinal cross-sectional view through a canister purge solenoid valve embodying principles of the invention and showing the valve in association with an evaporative emission control system.

Fig. 2 is an illustrative example of a schedule of operation for the valve.

Fig. 3 is an example of a pulse waveform for operating the valve according to a schedule depicted in Fig. 2.

Fig. 4 is an enlarged view of the valve seat by itself for illustrative purposes.

Fig. 5 is an enlarged view of the valve head by itself for illustrative purposes.

Description of the Preferred Embodiment

[0009] An evaporative emission control system 10 of a motor vehicle comprises a vapor collection canister 12 and a canister purge solenoid valve 14 connected in series between a fuel tank 16 and an intake manifold 18 of an internal combustion engine 20 in the customary fashion. An engine management computer 22 supplies a purge control signal for operating valve 14.

[0010] Valve 14 comprises a body 24 having an inlet port 26 that is coupled via a conduit 28 with canister 12 and an outlet port 30 that is coupled via a conduit 32 with intake manifold 18. Canister purg solenoid valve 14 has a longitudinal axis 34, and body 24 comprises a throughbore 36 that is coaxial with axis 34 and that in-

cludes inlet port 26. Outlet port 30 intercepts the wall of body 24 perpendicular to axis 34 so that port 30 and port 26 are at a right angle to each other proximate one longitudinal end of body 24.

[0011] The opposite longitudinal end comprises a radially outwardly directed circular flange 38 to which a solenoid 40 coaxial with axis 34 is attached in a manner that encloses that end of body 24. Solenoid 40 comprises a bobbin-mounted coil 42 and associated stator structure 44. The latter comprises pole pieces 46, 48 that are associated with opposite axial ends of coil 42, as shown, and a cylindrical casing 50 that bounds the outside of coil 42 between the radially outer margins of pole pieces 46, 48. Casing 50 also serves to hold parts of solenoid 40 together by having its lower margin crimped around the edge of flange 38 and its upper margin crimped around the edge of an end cap 52 that closes the far longitudinal end and that contains an electrical connector 54 having terminals to which leads from coil 42 are wired and to which engine management computer 22 is connected. The stator structure 44 further comprises an air gap 56 radialy inwardly of the bobbin wall of coil 42.

[0012] An armature 58 is disposed radially inwardly of pole pieces 46, 48 proximate air gap 56, and a valve member 60 is joined to armature 58 at the center thereof. Armature 58 comprises a generally cylindrical tube 62 with a transverse wall 66 spanning its interior about half-way along its length. It is to wall 66 that one end of valve member 60 is joined. A helical compression spring 64 is disposed between the inside of end cap 52 and the confronting face of wall 66 for biasing armature 58 and valve member 60 in the longitudinal direction toward port 26.

[0013] A tubular one-piece seat and guide member 68 is fitted to throughbore 36. It has a circular cylindrical sidewall and comprises a tapered valve seat 70 at the longitudinal end which is disposed proximate port 26. The longitudinally opposite end forms a guide that is lined by a circular cylindrical bushing 72 for guiding the longitudinal motion of valve member 60 when the valve is operated. The end of member 68 proximate port 26 fits against a shoulder 74 of body 24. Proximate its opposite end, member 68 comprises a circular flange 76 that fits against a should 78 of body 24. The insertion of bushing 72 into member 68 is set by a flange 80 fitting against the edge of member 68.

[0014] Valve member 60 is one-piece and comprises a cylindrical stem 82 that fits closely within the bore of bushing 72. The stem is diametrically reduced at 84 to provide for attachment to armature 58 while at the opposite end, it is diametrically reduced prior to an integral tapered valve head 86 at that end of the valve member. Head 86 is shaped for cooperation with the tapered valve seat. The attachment of valve member 60 to armature 58 comprises a joint that allows small radial displacement of the armature relative to th valve member, but without any axial separation. Valv memb r 60 is strictly guided by the clos , but lubrous, fit with bushing 72. The attachment involves fitting a multi-fingered spring 90 between wall 66 and a shoulder of member 60, placing a washer 92 on the opposit sid of wall 64, and then riveting the tip end of member 60 to capture the assembled parts. The rate of spring 90 is significantly more than that of spring 64.

[0015] Fig. 1 shows the closed position where the valve seats on the seat to block flow between ports 26 and 30. When the solenoid coil is progressively energized by current, armature 58 is pulled upwardly against the opposing spring force to unseat the valve from the seat and open the valve so that flow can occur between ports 26 and 30. The degree of valve opening depends on the magnitude of current flow through coil 42 so that by controlling the current flow, the purge flow through the valve is controlled.

[0016] Valve seat 70 and valve head 86 are contoured to cause sonic flow through the valve when the valve is open and there is at least a certain positive pressure differential across it, 150 millibars (127 mm Hg) for the present example. The creation of such a choked flow condition makes the valve rather insensitive to variations in manifold vacuum, accomplishing a vacuum regulating function without the inclusion of an additional vacuum regulating valve. Figs. 4 and 5 disclose dimensional details of an exemplary valve seat and valve head that are effective to cause sonic flow through the valve for positive pressure differential of at least 150 millibars. The frusto-conical seating surface of the valve head is designated 86a, and it is smooth and free of burrs and the like. The included angle of surface 86a is 31.04 degrees. Immediately below surface 86a is another frustoconical surface 86b having an included angle of 20.98 degrees. Below surface 86b is another frusto-conical surface 86c having an included angle of 25.40 degrees. The tip end of the valve head has a .50 mm radius. It is believed that the particular dimensions for these tapers and radius are especially important in achieving sonic flow. The included angle of valve seat 70 is 32.00 degrees.

[0017] The capability for achieving accurate control when open and avoiding leakage when closed is attained because of various features including: the sonic flow effect; the incorporation of the valve seat and the guide in a single part; the fact that the interface between the valve member and the bushing comprises lubrous material; the valve head and stem are a single part; by the fact that the valve member is joined with the armature by a joint that allows the armature to move slightly radially so as to be self-centering so that it does not contact the stator structure; and by making the seat area on which the valve head closes, at lease approximately the same area as that of the largest diameter of the stem, thus making the valve at least approximately balanced.

[0018] Figs. 2 and 3 disclose a control strategy for operating the valve in a manner that provides more accurat control, especially when the valve is operated in the

direction toward valve closing. Fig. 2 shows an operating mode containing several transitions in the duty cycle When the duty cycle is to be reduced, a gap is deliberately imposed in the duty cycle waveform. These gaps represent 0% duty cycle. Stated another way, certain decreases in duty cycle are preceded by a deliberate delay before the lower duty cycle is allowed to being.

Claims

1. A vapor collection system of an internal combustion engine fuel system comprising an electrically-operated canister purge valve (14) that is disposed between an intake manifold (18) of an engine (20) and a fuel vapor collection canister (12) which collects vapor generated by volatile fuel in a fuel tank (16), said canister purge valve comprising an electric actuator (40) and a valve body (24) that contains a valve head (86) and a valve seat (70) that are relatively positioned by said electric actuator in accordance with a purge control signal applied to said electric actuator to control the purging of fuel vapor collected in said canister to said intake manifold, **characterised in that** said valve head and said valve seat comprise respective axial wall portions (86a, 86b, 86c; 70) which are axially tapered and are mutually confronting to cause flow through the valve to be sonic flow when the valve is open and the pressure differential across it is in excess of a certain minimum and **in that** the valve head and stem are a single part, and by making the valve seat area on which the valve head closes at least approximately the same area as that of the largest diameter of the stem.

2. A vapor collection system as set forth in claim 1 **characterised further in that** said valve head is a portion of a one-piece valve member (60) that also comprises a stem (82), and said valve seat is a portion of a one-piece seat and guide member (68) that also comprises a guide, said one-piece member and said one-piece seat member share a common axis, a bushing (72) is disposed on said seat and guide member as a liner for said guide, said valve head is guided for axial motion relative to said valve seat by the fit of said valve stem with said bushing.

3. A vapor collection system as set forth in claim 1 **characterised further in that** said actuator comprises an armature (58) to which said valve member is attached by means of a joint (66, 84, 90, 92) that permits limited radial movement between them so that said armature can be self-centering within said actuator while said bushing axially guides said value stem.

4. A vapor collection system as set forth in claim 1 **haract ris d furth r in that** a duty cycl modulated waveform is applied to said actuator such that when said valve is to be op rated in th direction of closing, a deliberate gap is introduced into the waveform.

Patentansprüche

1. Dampfsammelanlage einer Brennkraftmaschinen-Kraftstoffanlage mit einem elektrisch betätigten Kanister-Spülventil (14), das zwischen einem Saugrohr (18) einer Brennkraftmaschine (20) und einem Kraftstoffdampf-Sammelkanister (12) angeordnet ist, welcher durch flüchtigen Kraftstoff in einem Kraftstofftank (16) erzeugten Dampf sammelt, wobei das Kanister-Spülventil eine elektrische Betätigungsvorrichtung (40) und ein Ventilgehäuse (24) mit einem Ventilkopf (86) und einem Ventilsitz (70) aufweist, welche von der elektrischen Betätigungsvorrichtung in Abhängigkeit von einem an die elektrische Betätigungsvorrichtung angelegten Spülsteuersignal relativ zueinander positioniert werden, um die Abgabe von im Kanister gesammeltem Kraftstoffdampf an das Saugrohr zu steuern, **dadurch gekennzeichnet, daß** der Ventilkopf und der Ventilsitz entsprechende axiale Wandabschnitte (86a, 86b, 86c; 70) aufweisen, die axial schräg verlaufend ausgebildet und einander zugewandt sind, derart, daß die Strömung durch das Ventil mit Schallgeschwindigkeit erfolgt, wenn das Ventil offen ist und der an ihm anliegende Druckunterschied ein vorgegebenes Minimum überschreitet, und dass der Ventilkopf und Schaft ein einzelnes Teil sind, wobei der Ventilsitzbereich, an dem der Ventilkopf schließend anliegt, mindestens näherungsweise der gleiche Bereich wie der des größten Durchmessers des Schaftes gemacht wird.

2. Dampfsammelanlage nach Anspruch 1, **dadurch gekennzeichnet, daß** der Ventilkopf ein Teil eines einstückigen Ventilgliedes (60) ist, das ferner einen Schaft (82) aufweist, und daß der Ventilsitz ein Teil eines einstückigen Sitz- und Führungsgliedes (68) ist, welches ferner eine Führung aufweist, daß das einstückige Ventilglied und das einstückige Sitz- und Führungsglied eine gemeinsame Achse teilen, daß eine Buchse (72) auf dem Sitz- und Führungsglied als Umhüllung der Führung angeordnet ist, und daß der Ventilkopf durch die Passung zwischen dem Ventilschaft und der Buchse axial beweglich relativ zu dem Ventilsitz geführt ist.

3. Dampfsammelanlage nach Anspruch 1, **dadurch gekennzeichnet, daß** die Betätigungsvorrichtung einen Anker (58) aufweist, an d m das Ventilglied durch eine Verbindung (86, 84, 90, 92) befestigt ist, die eine begrenzte Radialbewegung zwischen ih-

nen zuläßt, so daß der Ank r innerhalb der Betätigungsvorrichtung s lbstzentrierend ist, während die Buchse den Ventilschaft axial führt.

4. Dampfsammelanlage nach Anspruch 1, **dadurch gekennzeichnet, daß** an die Betätigungsvorrichtung ein pulsweitenmoduliertes Signal angelegt wird, derart, daß bei einer Betätigung des Ventils in Schließrichtung eine absichtliche Lücke in dem Signal erzeugt wird.

Revendications

1. Système de collection de vapeurs d'un système d'alimentation en carburant de moteur à combustion interne, comprenant une vanne de purge de cartouche commandée électriquement (14) qui est disposée entre un collecteur d'admission (18) d'un moteur (20) et une cartouche de collection des vapeurs de carburant (12) qui recueille les vapeurs générées par un carburant volatil dans un réservoir de carburant (16), ladite vanne de purge de cartouche comprenant un actionneur électrique (40) et un corps de vanne (24) qui contient une tête de vanne (86) et un siège de vanne (70) qui sont positionnés de façon relative par ledit actionneur électrique conformément à un signal de commande de purge appliqué audit actionneur électrique afin de commander l'évacuation des vapeurs de carburant recueillies dans ladite cartouche vers ledit collecteur d'admission, **caractérisé en ce que** ladite tête de vanne et ledit siège de vanne comprennent des parties de paroi axiale respectives (86a, 86b, 86c ; 70) qui sont effilées axialement et sont mutuellement en regard afin d'amener l'écoulement au travers de la vanne à être un écoulement sonique lorsque la vanne est ouverte et que la différence de pression à travers celle-ci dépasse un certain minimum et **en ce que** la tête et la tige de vanne forment une seule pièce, et **en ce que** la section du siège de vanne sur laquelle la tête de vanne vient se fermer est au moins approximativement identique à la section de plus large diamètre de la tige.

2. Système de collection de vapeurs selon la revendication 1, **caractérisé en outre en ce que** ladite tête de vanne est une partie d'un élément de vanne en une seule pièce (60) qui comprend également une tige (82), et ledit siège de vanne est une partie d'un élément de siège et de guide en une seule pièce (68) qui comprend également un guide, ledit élément de vanne en une seule pièce et ledit élément de siège en une seule pièce partagent un axe commun, une douille (72) est disposée sur ledit élément de siège et de guide en tant que doublage dudit guide, ladite tête de vanne est guidée dans son mouvement axial par rapport audit siège de vanne par l'ajustement d ladite tige de vann avec ladite douille.

3. Système de collection de vap urs selon la revendication 1, **ara t´ris´ n outre n qu** ledit actionneur comprend un noyau plongeur (58) auquel ledit élément de vanne est fixé au moyen d'un joint (66, 84, 90, 92) qui permet un mouvement radial limité entre eux de sorte que ledit noyau plongeur peut se centrer automatiquement à l'intérieur dudit actionneur tandis que ladite douille guide axialement ladite tige de vanne.

4. Système de collection de vapeurs selon la revendication 1, **caractérisé en outre en ce qu'**une forme d'onde modulée en rapport cyclique est appliquée audit actionneur de manière telle que lorsque ladite vanne doit être mise en oeuvre dans le sens de la fermeture, un intervalle délibéré est introduit dans la forme d'onde.

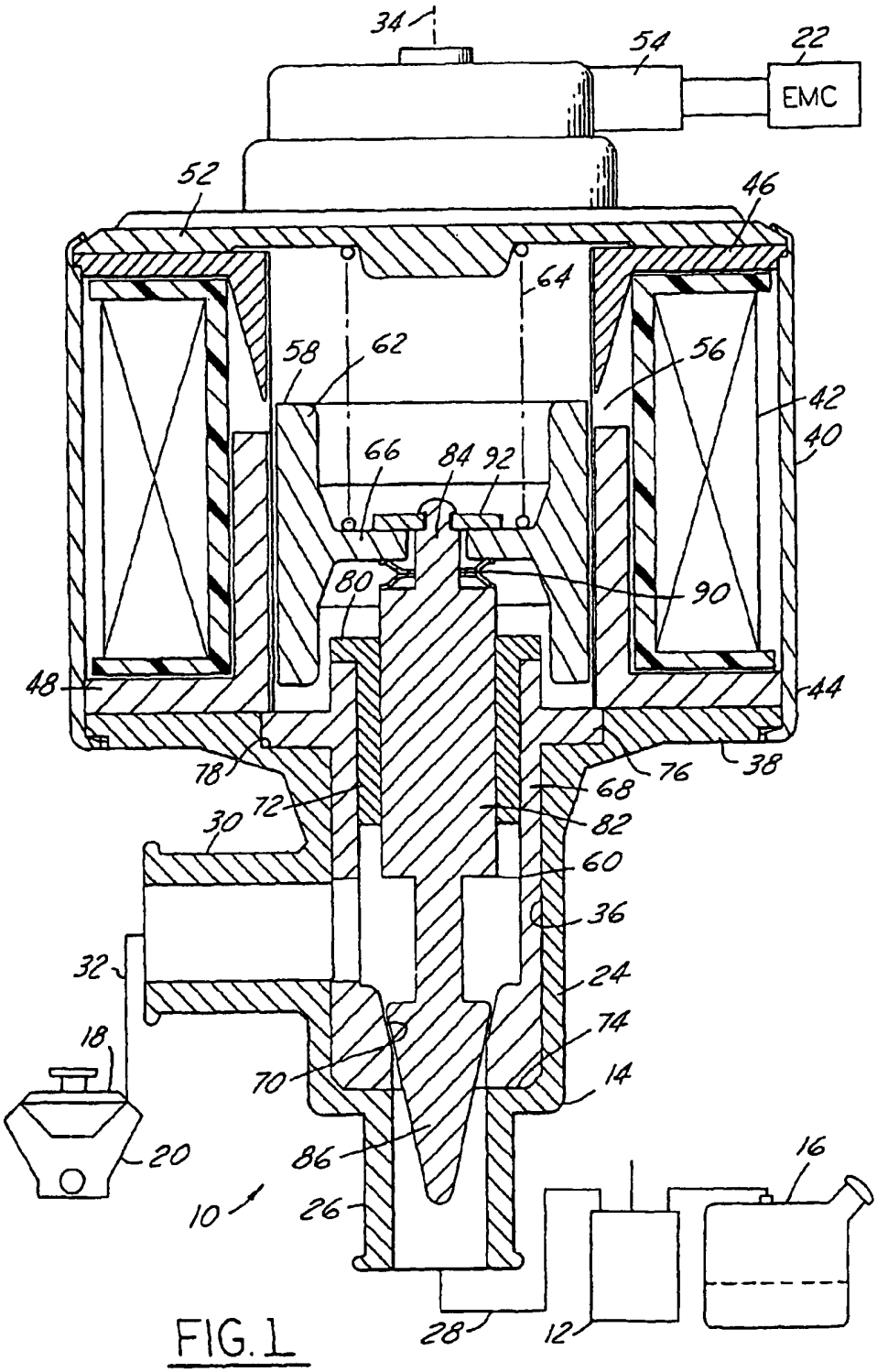
34
54
22
EMC
52
46
64
58
62
56
42
40
66
84
92
80
90
48
44
78
76
38
72
68
30
82
60
36
32
24
18
74
70
14
20
86
16
10
26
28
12

FIG. 1

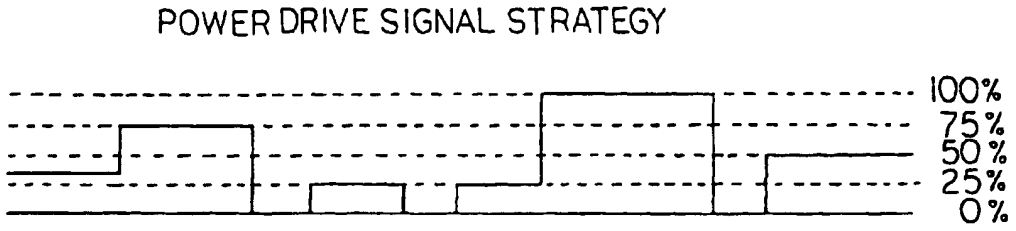
POWER DRIVE SIGNAL STRATEGY
100%
75%
50%
25%
0%

FIG.2

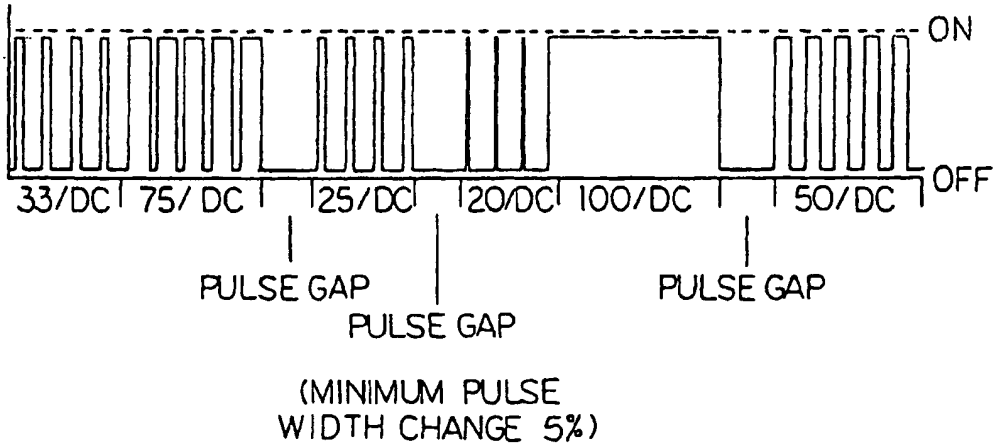
ON
OFF
33/DC
75/ DC
25/DC
20/DC
100/DC
50/DC
PULSE GAP
PULSE GAP
PULSE GAP
(MINIMUM PULSE
WIDTH CHANGE 5%)

FIG.3

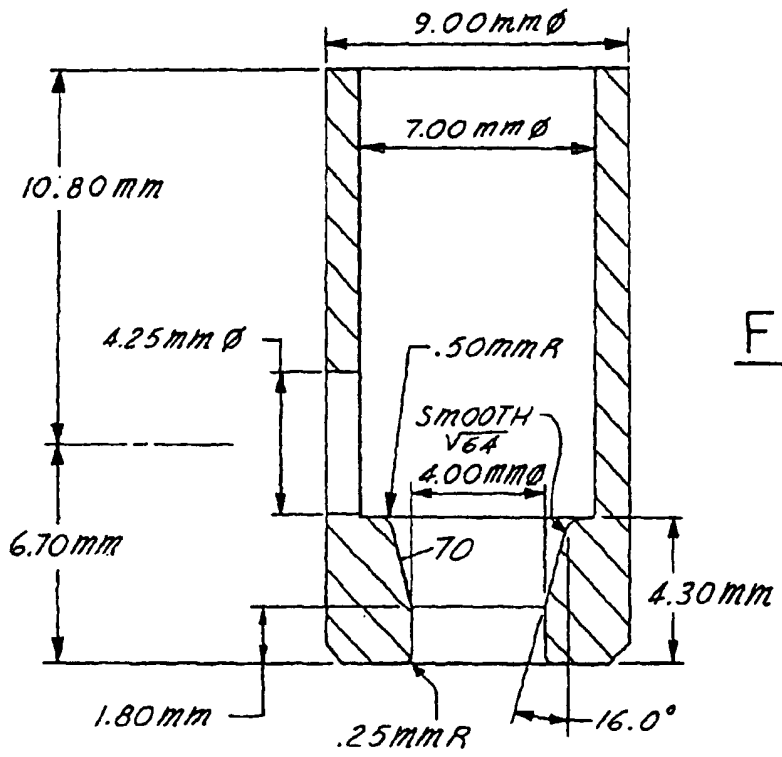
9.00mmØ
7.00mmØ
10.80mm
4.25mmØ
.50mmR
SMOOTH
√64
4.00mmØ
6.70mm
70
4.30mm
1.80mm
.25mmR
16.0°

FIG.4

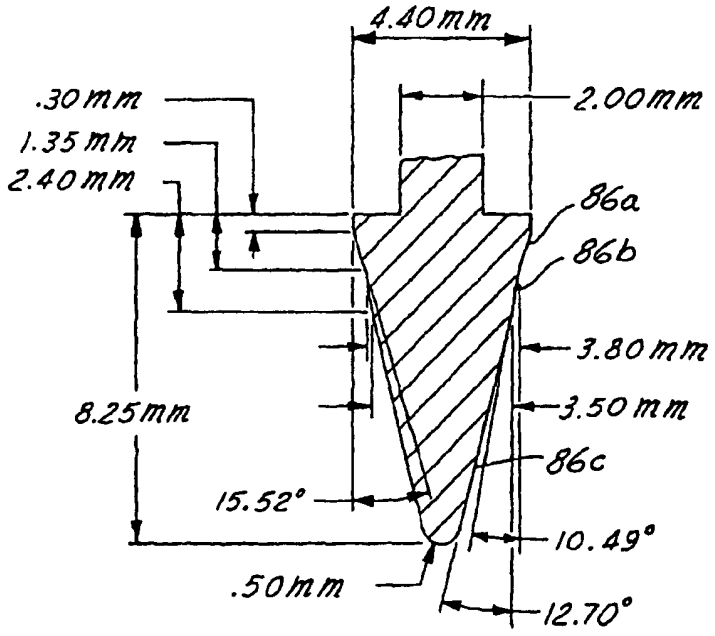
4.40mm
.30mm
1.35mm
2.40mm
2.00mm
86a
86b
3.80mm
3.50mm
8.25mm
86c
15.52°
10.49°
.50mm
12.70°

FIG.5